



VALANCE SOLUTIONS

Capstone Design Document

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PINEWOOD DERBY MANAGEMENT SYSTEM

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Revision Sheet

Release No.	Date	Revision Description
1	10/26/09	Changed the functional requirements and other minor changes
2	11/8/09	Updated dates and figures etc.
3	11/23/09	Final edits and updated requirements

Capstone Design Document

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1.0 PWDMS INTRODUCTION

1.0 PWDMS INTRODUCTION

The Pinewood Derby Management System, or PWDMS, is a prototype that Valance Solutions is developing which aims to simplify the act of organizing and running a Cub Scout Pinewood Derby. The prototype will be delivered to Paragon Innovations by May 2010 where further product development may occur. The organizations which purchase the product will benefit from a less stressful derby so that all involved can focus on what is truly important: having a good time!

1.1 Problem Statement

Pinewood Derbies are annual events, held worldwide, and run by volunteers in each community. Many volunteers involved with the process have stated that the event is one of the most rewarding, yet stressful, events held all year. These events include multiple kids building gravity propelled wooden cars to race down a Pinewood Derby track. During the event, tempers and stress often run high as human error and issues are bound to occur as in any volunteer based work.

Tasks of an ordinary Pinewood Derby include:

Before the Derby

- Registering the cars beforehand
- Checking for compliance with car regulations such as weight and size

During the Derby

- Gathering and recording the times and results of each race
 - Update the tournament brackets
 - Announce the winners that advance and the others that play in consolation brackets
 - Announce the times of each car
- Place appropriate cars on appropriate lane for next race
 - Randomize car placement to account for lane deviations
 - Announce the start of following race

- Manually fix errors that occur such as timing errors or track errors (i.e., a car falls off the track etc)

After the Derby

- Calculate the average times of each car
- Display/announce final results
- Hand out awards and certificates

These tasks traditionally take multiple volunteers, many of which have little to no experience in running a derby. Yet, with such a high demand for a solution to simplify the Pinewood Derby process, all current attempts have fallen short.

The aforementioned difficulties of organizing and running a Pinewood Derby have led to the creation of this problem statement:

“No current solution offers a complete, fully integrated Pinewood Derby timing and management system with a focus on simplicity for the user.”

1.2 Functional Requirements

In order for the PWDMS to be completed, several requirements must be met. This section includes agreed upon requirements through Valance Solutions and Paragon Innovations and will be updated as needed throughout the project. This section will provide a simplified listing of the requirements while further explanation will be provided in section 1.4.

Timing

- No moving parts
- Timing for 4 lanes and 2 additional add-on modules
- Timing start based on start gate beam break (not starting gate movement)

Communication

- Interface to PC(s) and track timing system can be wired or wireless (no RS-232)

Race Support Features

- Automatic race scheduling including:
 - Stearns Method
 - Lane Rotation
 - Double Elimination
- Estimated race time prior to and updated during race
- Support for “tagging” car numbers
- Able to indicate the proper lane for each tagged car prior to start
- Only include qualified cars in scheduling
- Display current standings
- Display results of last 3 races
- Display of cars and results for any race
- Display of racing and “on deck” cars (up to 3 deep)

Scoring

- Cumulative time (drop worst option)
- Average time (drop worst option)
- Best time
- Cumulative points
- Separate scores for different competition (age) groups
- Run tie breakers, optional based on scoring
- Accumulate lane and car statistics

Reports

- Results by Unit/Competitive (age) category/Overall
- Reports printable from any computer on ad-hoc network
- Able to print official race rules
- Registration data reports
- Paid fees and Qualifications

Race Planning

- Forms based selection of rules, scheduling methods, and scoring
- Ability to pre-register

Registration

- Support for multiple registration stations
- Registration stations can interface with tag reader
- Support for self-registration (except for vehicle check and fees)
- Support for registering multiple races while another is in progress
- Support for multiple qualification stations

Installation

- Installable on wooden and aluminum tracks
- Mounting configurable to different lane spacing and track widths
- Minimum set up wiring with commonly available (Radio Shack, Fry's, Best Buy) cables or wire.
- Assembly (after 1st initial setup) requires only household tools, hammer, Phillips or slotted screw driver (#1 or larger), slip joint pliers, or adjustable spanner, etc.
- Timing system verification without setting up a "race"
- Installation and operation of ad-hoc network for user computer stations
- Print setup instructions from software

Power

- Power will be either off the shelf, UL listed, low voltage power supplies (wall warts) or batteries
 - If batteries are used for any module in the system they must meet the following criteria:
 - 10 hours continuous operation without changing
 - Compatible with the following chemistries Alkaline, NMIH, NICAD
 - Common sizes AA preferred, AAA or C acceptable
- Out of the wall powered, 9 to 12 volt

1.3 Conceptual Block Diagram

The conceptual block diagram on the following page gives a top down view of how the overall system will operate.

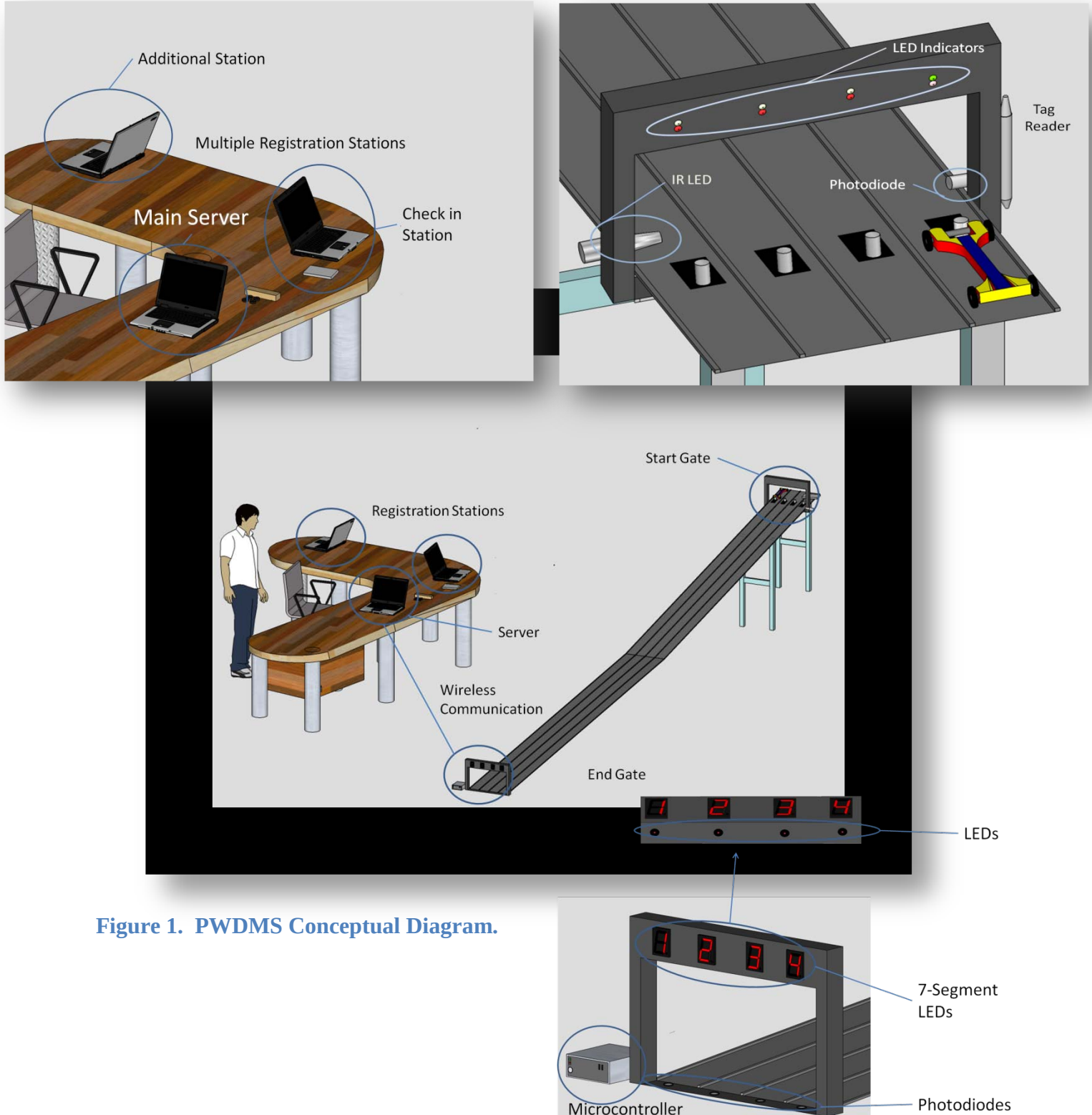


Figure 1. PWDMS Conceptual Diagram.

The conceptual block diagram shows that the PWDMS has two main sections: The software on the server and the track which is divided into two more sections, the start gate and timing gate.

1.3.1 Server

The server will be created with the user's own computer by installing the Apache software provided. Apache is a widely used server that can operate on multiple systems. The server will allow the user to perform such task as registering participants, race scheduling, tabulating results, displaying results, and printing certificates. The software that is being used is very flexible and scalable. If more functions are needed in the future, the addition of more features will be easy to implement.

The registration of participants will take advantage of the Apache software. Multiple computers will be able to access the registration forms from the server through the TCP/IP protocol. The event operators will have the choice to layout their own registration stations and/or allow users with their own computers to preregister. If the event operators allow participants to preregister, information about the participant will be stored in the database for finalization of the entry.

Race scheduling will be done through the use of PHP. PHP allows the use of software objects, making programming the scheduling algorithm readable for future engineers. The event operators will have the choice to schedule the race in several ways. Double elimination, lane rotation, and Stearns method are some of the ways that the race can be scheduled.

The tabulation and displaying of results will also be implemented using PHP programming. PHP has similar semantics to the C/C++ programming language and therefore will be easy to pick up for future engineers familiar with C/C++. The tabulation of scores should hold no difficulty if they need to be changed in the future. Since the server can be accessed by any computer that has a wireless card, the results can be accessed at any point during the race. The results can also be

displayed using a projector via a video port on any computer which has access to the server through Wi-Fi.

1.3.2 Start Gate

The start gate will be a peripheral board that will connect to the main timing unit. It will be connected via wires that will run along the bottom of the track. The purpose of the start gate, as shown in the conceptual diagram is to provide three main components.

- The tag reader
- Status LEDs
- Start gate IR LED and photodiode

Tag Reader

Although the reader is placed on top of the track for visibility in the conceptual diagram, the actual placement will not constrict the placement of the Pinewood Derby cars. Current implementation of tagging will either take place using RFID or barcode technology. This decision is discussed in more detail under section 2.1: Technology Survey Assessment. Upon the successful read of a tag, the corresponding Status LED above the appropriate track turns green. This will help in reducing human error.

Status LEDs

These LEDs will be placed above each lane and will communicate information from the tag reader to the user by indicating the proper lane for each car. Either multiple LEDs or a multicolored LED will be used.

Start gate IR LED and photodiode

These two components will create a path in which the cars will cross at the beginning of each race. Upon crossing the photodiode's light path, the time will start for all cars. Thus, with one LED and photodiode, the time for all cars can be started at the same time.

1.3.3 Timing Gate

The timing gate will contain the microcontroller enclosure as well as the other timing peripherals. The microcontroller is displayed outside of the timing unit for display purposes in the conceptual diagram. This enclosure will contain:

- PIC32
- Communication devices
- 7 segment LEDs
- IR LEDs and photodiodes

PIC32

This will be the central controller for all track operation. It will receive commands from the server, calculate the results of the race, and send them back to the server. It will also send commands to all peripheral components such as status LEDs and 7 segment displays.

Communication devices

These devices will send data wirelessly or via Ethernet to the server.

7 segment LEDs

These will be the primary display units for the track. Each lane will have its own 7 segment LEDs to display the results of the race.

IR LEDs and photodiodes

These will be the timing components for the system. Once a car crosses the beam between each lane, the time is captured on the PIC32 and stored.

1.4 Performance Requirements

These performance requirements are an elaboration of the functional requirements and explain the intent and specifics of each requirement as needed. Like the functional requirements, they are scheduled to change and be updated as the project moves forward.

Timing

- No moving parts
 - Components that start and stop the timer for each lane will not be mechanical
 - Optoelectronics integrated into the start gate and the finish gate
- Timing for 4 lanes and 2 additional single lane add-on modules
 - Hardware and software can accommodate the timing of a 4 lane prototype as well as a 6 lane prototype.
- Timing start based on start gate beam break (not starting gate movement)
 - Resolution of 1 millisecond minimum
 - Times must be saved with this resolution but not necessarily displayed on the track with this resolution
- Accuracy +/- 5 milliseconds minimum
 - The final time for each car that is recorded will account for the various delays associated with timing. Any delay that will affect the accuracy beyond the 5 milliseconds minimum will be adjusted through software. These delays consist of:
 - Propagation delay from the start gate to the microcontroller (40ft)
 - Clock cycle delay, or the number of clock cycles it takes the microcontroller to recognize an input from the timing sensors after it has been received
 - Timing sensor's operational delay, or the time it takes for the start sensor to send a signal once the car has crossed the beam
- Electronic Lane to lane deviation +/- 1 millisecond minimum
 - The accuracy of one lane will not be 1 millisecond different than any other lane
 - Can be tested by using a level surface, such as a wooden board, to stop all lane timers at roughly the same time
 - Alternative test, terminate power on all optic sensors at the same time; verify 1 millisecond accuracy

Communication

- Interface to PC(s) and track timing system can be wired or wireless (no RS-232)

Race Support Features

- Automatic race scheduling including:
 - Stearns Method



- Every car races the same number of times
 - Every car races in each round and every car races in each lane
 - Software will have a method to take care of time constraints
- Lane Rotation
- Double Elimination
- Estimated race time prior to and updated during race
 - Will be updated according to statistics provided at the beginning of the derby
- Support for “tagging” car numbers
 - A car does not have to be tagged to participate
 - The tag will associate the car with the car number in software and will be incorporated into registration as well as lane indication
 - Tag is not intended to take place of standard car number stickers
- Able to indicate the proper lane for each tagged car prior to start
 - Tag reader at the start gate can indicate in which lane the tagged car is scheduled to race
 - Intended to reduce, not eliminate, the amount of human error during a derby
- Only include qualified cars in scheduling
 - Prior to start, each car that will participate must have a qualified status in the software before it is incorporated into race scheduling
 - The qualified status is determined by the event operator
- Display current standings
 - Web page accessible via server or computer connected to server that will display general information about race results
 - Displays, as a minimum, the current derby leaders (top 3)
- Display results of last 3 races
 - Web page accessible via server or computer connected to server that will display general information about race results
 - Webpage can be its own page or merged with other race statistic webpages
- Display of cars and results for any race
 - Web page accessible via server or computer connected to server that will display general information about race results
 - Webpage can be its own page or merged with other race statistic webpages
- Display of racing and “on deck” cars (up to 3 deep)
 - Web page accessible via server or computer connected to server that will display general information about race results
 - Webpage can be its own page or merged with other race statistic webpages

Scoring

- Cumulative time (drop worst option)
- Average time (drop worst option)
- Best time
- Cumulative points
 - For lane rotation scheduling only
- Separate scores for different competition (age) groups

- Run tie breakers, optional based on scoring
 - When a tie occurs, the event operator has the choice of allowing the tied cars to race amongst themselves
 - Tie braking race should be carried out immediately following the tie
- Accumulate lane and car statistics

Reports

- Results by Unit/Competitive (age) category/Overall
 - Report will include same results under the scoring section
 - Will be displayed on an HTML page
 - Printing will be done as a web page from the web browser
- Reports printable from any computer on ad-hoc network
 - Printing will be done as a web page from the web browser
- Able to print official race rules
 - Printing will be done as a web page from the web browser
- Registration data reports
 - Printing will be done as a web page from the web browser
- Paid fees and Qualifications
 - Printing will be done as a web page from the web browser

Race Planning

- Form based selection of rules, scheduling methods, and scoring
 - Rules, scheduling, and scoring will conform to the requirements stated in each
- Ability to pre-register
 - Contestant can be assigned a tag beforehand
 - Contestants' info can be entered into records beforehand and saved till registration

Registration

- Support for multiple registration stations
 - Computers can connect to server via web browser to serve as registration station
 - 3 as a minimum
- Registration stations can interface with tag reader
- Support for self-registration (except for vehicle check and fees)
 - Individual can come to on-site registration station and fill out entry form
- Support for registering multiple races while another is in progress
 - Software is capable of separating different contestants into different races
 - Does not imply that software can send commands to two separate tracks (races) at the same time
- Support for multiple qualification stations
 - Computers can connect to server via web browser to serve as registration station
 - 3 as a minimum

Installation

- Installable on wooden and aluminum tracks
- Mounting configurable to different lane spacing and track widths



- Timing sensors will line up properly with lanes using standard 3.5 to 4 inches per lane
- Minimum set up wiring with commonly available (Radio Shack, Fry's, Best Buy) cables or wire.
- Assembly (after 1st initial setup) requires only household tools, hammer, phillips or slotted screw driver (#1 or larger), slip joint pliers, or adjustable spanner, etc.
- Timing system verification without setting up a "race"
 - Timing sensor alignment will have status indicators for each lane
- Installation and operation of ad-hoc network for user computer stations
 - At least 1 server, 3 registration station, and 3 qualification stations can send data to the server's database
- Print setup instructions from software
 - Printing will be done as a web page from the web browser

Power

- Power supply will be either a UL listed low voltage power supply (wall warts) or battery
 - If batteries are used for any module in the system they must meet the following criteria:
 - 10 hours continuous operation without charging
 - Compatible with the following chemistries: Alkaline, NMIH, or NICAD
 - Common sizes: AA preferred, AAA or C acceptable
- If wall wart or equivalent
 - 9 to 12 volt
- Replacement should be purchasable at common electronic stores

2.0 TECHNOLOGICAL OVERVIEW

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Creating a management solution such as the PWDMS requires the use of various technological capabilities. This section details the manner in which Valance Solutions will employ the various technologies.

2.1 Technology Survey Assessment

This survey assessment will compare the given pros and cons of different technological choices Valance Solutions can make in completing the PWDMS. Although several choices in each category are competitive, the products that give Valance Solutions the greatest chance of success will be selected. The areas of decision are:

- Microcontroller Architecture
- Actual Microcontroller
- Display Screens
- Communication Devices
- Tagging System
- Signal Conditioning
- Enclosure



Table 1. Microcontroller Architecture.

Microcontroller Architecture		
Type	Pros	Cons
Basic Stamp 2	— Lots of web examples — Easy to setup hardware — Cross-Platform	— Slow, code is interpreted, not compiled (BASIC) — Base unit price not competitive
BasicX (BX-24) and BasicMicro	— Faster than BS2 — More features than BS2 (timers, ADCs, etc.)	— Windows only — Base unit price not competitive
PIC Microcontroller	— Wide variety — Fast performance — Excellent documentation — Simple IDE (MPLab) — Price: \$1 to \$15 per unit — Compatible with various peripheral boards (i.e., ZeroG)	— Initial setup ~ \$300 — Requires external programmer — Peripheral limits
AVR Microcontrollers	— Wide variety — Fast performance — Lots of DIY project documentation — Price - \$1 to \$15 per unit — Programmers are less expensive — Higher Code Density than PIC	— Complex IDE solutions — Initial setup is notoriously difficult — Peripheral limits
PowerPC Microcontrollers	— Similar to PIC and AVR in performance — Fewer Peripheral limits	— Base unit price is not competitive — Complex

The PIC microcontroller was chosen because of the qualities listed above. The price combined with the documentation made this avenue the most attractive. Several team members have experience with Microchip products and feel confident in its ability to accomplish the tasks required of the PWDMS.



Table 2. PIC comparisons.

PIC		
Type	Pros	Cons
PIC24	— Less expensive	— Slower clock speeds — Smaller register sizes
dsPIC33	— Less expensive	— Slower clock speeds — Smaller register sizes
PIC32	— Faster clock speeds — Larger register sizes — Updated architecture — Allows for future expansion	— Roughly \$5 more expensive

The PIC32 architecture was chosen because it has all the features needed to meet requirements. It has the clock speeds needed, multiple I/O ports, up to date architecture, and will allow for future expansion if necessary. Although, the single unit price is \$5 more than the dsPIC33, the PIC32's features will outweigh the cost.

Table 3. Display Screen Comparisons.

Display Screens		
Type	Pros	Cons
LCD	— Standard interface — Back-lit — High versatility and flexibility	— Affordable models look out dated — Lack of color — Expensive — Complex to program — Affordable units are smaller
Seven Segment	— Modern Design (appearance) — Inexpensive (Large units) — Bright — Easy to program	— Character limit — Limit to information displayed

The seven segment display, although it does not look as appealing as the LCD screens, will be used. A large LCD would be needed to provide visibility for the spectators. These large LCD

screens are too costly to implement in the prototype. Seven segment displays will be used because of their price and modularity.

Table 4. Communication Device Comparisons.

Communication Devices		
Type	Pros	Cons
Zigbee	— Low Power — Low Cost — Moderate range	— Limits expansion (small data rate) — Limits expansion (computer adaptors needed for each computer)
Bluetooth	— Low Power — Low Cost — Longer Range than Zigbee	— Adds complexity — Bluetooth not available on majority of computers
AC164132 / AC164136- (Ethernet / Wi-Fi PICtail Plus Daughter Board)	— Works with wireless / Ethernet devices (laptops, computers, etc.) — Pre-built by Microchip (saves time) — Tested and guaranteed — Range and Data rate allows for future expansion — Royalty free implementation	— Initial expense is higher
Custom Design	— Save production costs — Able to be modified to fit needs	— Extensive research, planning, designing, implementation, and testing required — Increases designing costs

Although the custom design would be best given an increase in design time and budget, the scope of the project best fits the PICtail Plus Daughter Boards from Microchip.



Table 5. Tagging System Comparisons.

Tagging System		
Type	Pros	Cons
Barcode	— Low Cost — Can be obtained easily from retail stores — Printable labels	— Limits expansion (small data rate) — Line of sight needed
RFID	— Low cost — Easier to read tags — Wow factor	— Hard to obtain — Expensive tags

Both types of readers have similar pros and cons. Currently, there has not been an official decision on which will be used. The decision will require more research into the ability to print tags. Since the reader for both types of technology are similar, the tags themselves will determine the decision. Implementation of either reader will be similar in nature.

Table 6. Signal Conditioning Comparisons.

Signal Conditioning		
Type	Pros	Cons
ispPAC20	— Customizable filtration — Customizable amplification — Programmable	— Must learn programming language — Added complexity
Custom Filters	— Controllable physical hardware — Simple to implement	— Accuracy Issues — Complex arrangements may be used to achieve necessary values — Difficult to alter/change once in place

The ispPAC20 In-System Programmable Signal Conditioning microchip was chosen because of its customizable and dynamically programmable capabilities. Although custom built filters and amplifiers would work, the ispPAC20 can accomplish all of the tasks necessary to condition an

input signal from the sensors to the PIC32. The only drawback to using the ispPAC20 is the understanding of programming the ispPAC20 properly using IEEE Standard 1149.1 (JTAG).

Table 7. Enclosure Comparisons.

Enclosure		
Type	Pros	Cons
Molded Plastic	— Inexpensive to purchase	— Less durable
Aluminum	— Durable — Professional look and feel	— Expensive — Possible electrical shorts
Combo Aluminum / Plexiglas	— Durable — Professional look and feel — Reduce Risk of electrical shorts	— More expensive than plastic

The enclosure will be the housing of all the components on both the start and finish gate. An Aluminum and Plexiglas combination has been chosen for its durability and reduced probability to cause an electrical short.

2.2 Detailed Functional Block Diagrams

The functional block diagrams will detail the components of the system as a whole as well as the track timing/display board and the track start/tagging board.

2.2.1 Overview

The Pinewood Derby Management System will consist of three major hardware components and a software-based server database. These three hardware components consist of a main PCB, a start gate, and a finish line. Each of these components will contain hardware that is specific to its purpose, while both the start gate and finish line will communicate with the main PCB to share timing, lane-specific, and car-specific data. Each of these components serves a specific purpose within the PWDMS.

The Infrared LED to Photodiode configuration details the timing sensors at both the Start Gate and Finish Line. In the case of the Start Gate, there will be only one sensor across the width of

the track. When the race begins and a car crosses the beam, the timing signal will be sent through a signal conditioning chip to the PIC32 where the race time will begin.

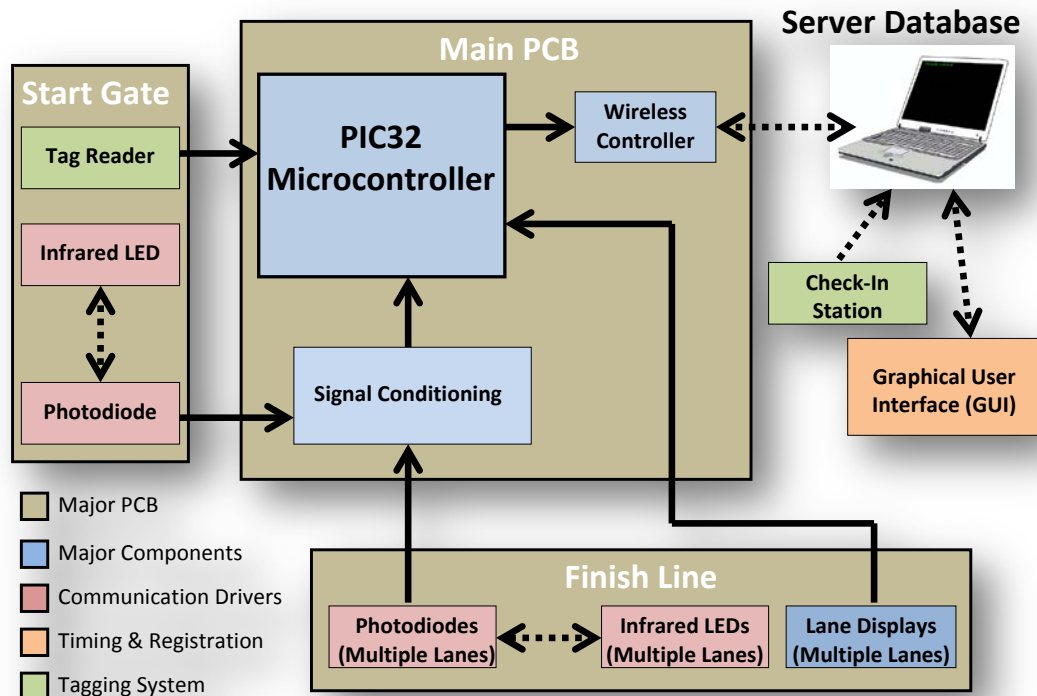


Figure 2. Top down view of system.

As the cars cross the finish line individually, a lane-specific pair of Infrared LED to Photodiode sensors will be tripped. As the signals are again sent back through a signal conditioning chip, the PIC32 will store the completed race time for each individual lane. The PIC32 will then display the appropriate data above each lane through the seven segment display. Simultaneously, the PIC32 will send the timing data through the communication controllers (i.e. Zero-G Wireless module or Ethernet Controller) to the database for record keeping in conjunction with the car-specific data recorded at registration.

The Server Database component of the PWDMS is the software compliment to the hardware designed for the timing system and processing of race information. This database will be

implemented not only for the cataloging/record-keeping of race information and timing data but also will be used for the overall race management. The server database is the heart of the PWDMS because it enables registration, unique tagging of individual cars, race management, race design, record keeping, and timing association. Through wireless communication with the PIC32 Microprocessor, the server database will follow a specific race design (Stern's Method, Double Elimination, Lane Rotation, etc.) and manage the car placement through a graphical user interface. This unique GUI will assist the race operator in managing the races throughout the day. Multiple registration kiosks will also be supported by this server and can be accessed by any laptop through the TCP/IP protocol. After the races are finished, the software will create certificates and race reports which may be printed for distribution among the competitors.

2.2.2 Main Microcontroller Board

The Main PCB is the brain of the PWDMS housing the PIC32 Microprocessor, the signal conditioning hardware, and the ZeroG wireless communication controller. This major component of the PWDMS will be the main processing unit as well as the center of all communication within the hardware of the system. At the beginning of the race, a signal will be received from the Photodiode-Infrared LED pair from the start gate. To ensure this signal was in fact not a false positive, the signal will be passed through signal conditioning hardware before being passed onto the PIC32. Once received, the PIC32 will begin the timing for each lane.

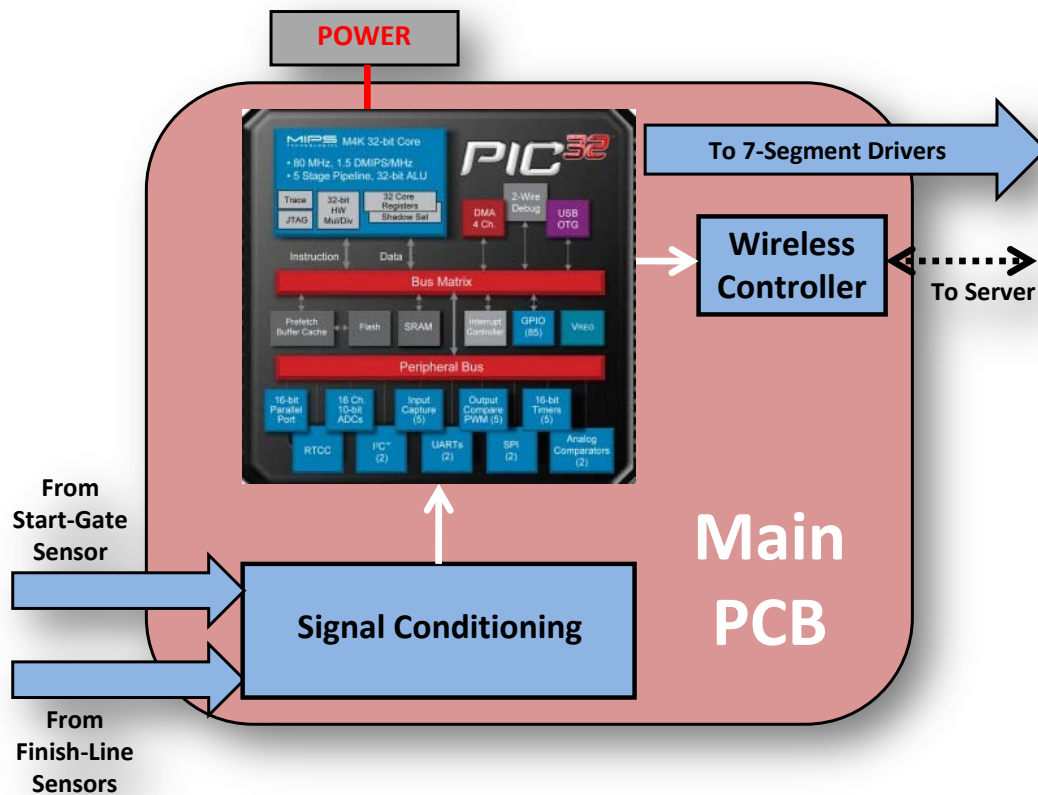


Figure 3. Main controller Board diagram.

As each car passes through the finish line, a lane-specific signal will be sent from each Photodiode-Infrared LED pair through the signal conditioning hardware and on to the PIC32. Once received the PIC32 will stop the timing for each lane, process the data, and send the correct information to each of the lane displays while simultaneously sending the timing and race data to the server database for cataloging. This board will be powered with a UL listed wall-plug power and, through multiple power management and voltage regulation configurations, will power each of the microchips on the board.

2.2.4 Track Start Gate and Tagging Board

The Start Gate of the PWDMS serves two main purposes. First, the start gate will read each car's unique tag through the tag reader and send the information down to the PIC32 for verification. This process is used to help reduce human error and verify that each car on the track is not only

in the correct race, but the correct lane. This information is crucial when implementing the Stern's Method and the Lane Rotation Method of race planning. When each car tag is read and it is determined that the car is, in fact, in the proper lane, a status LED will light up 'green' above the lane. The lane-specific status LED will light up 'red' if there is any problem with the car's lane placement.

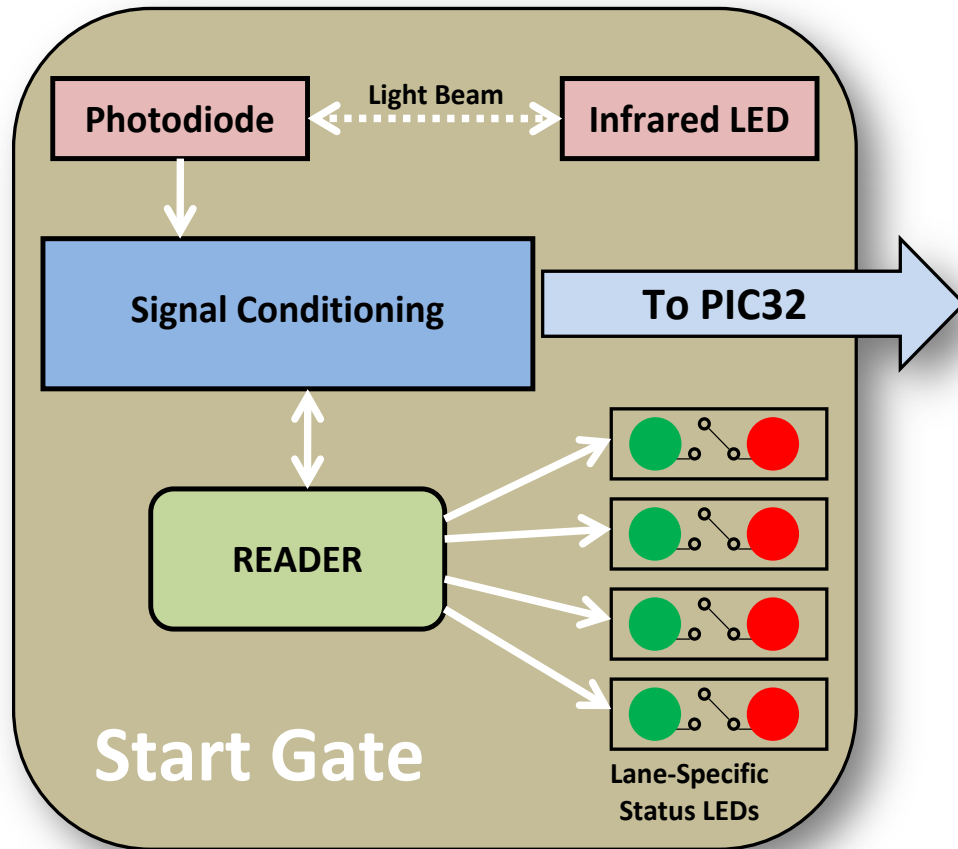


Figure 4. Peripheral diagram.

Once the race operator begins the race and drops the pegs, the cars will begin their decent down the track. As the first car passes through the single Photodiode-Infrared LED pair aligned across the width of the track, the sensors will send their signal through signal conditioning hardware to ensure there was not a false positive pulse before transmitting the data to the Main PCB for processing.

2.2.3 Finish Line

Similar to the start gate, the Finish Line is two major functions. These functions, however, differ in the fact that they are designed for lane-specific purposes. As a race ends, each car passes through the finish line. Because this is a timed competition, each lane and each car must have lane specific timing data. As each car passes through the finish line, the car will break a lane-specific Photodiode-Infrared LED pair arranged in a vertical alignment perpendicular to each lane. Once the beam is broken, the signal is sent directly to the Main PCB for signal conditioning and processing. The signals may differ by only milliseconds.

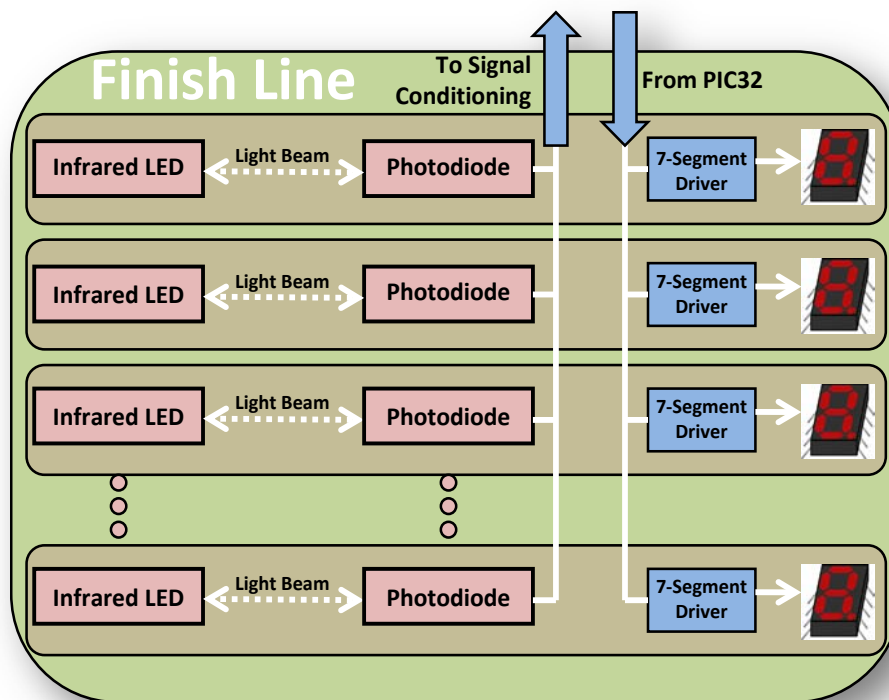


Figure 5. Peripheral diagram.

After the race has ended and the lane-specific timing data has been processed, the PIC32 will send a package of lane-specific display data to each appropriate lane. This data will include the car's placement in the race (First, Second, Third, etc.) as well as the car's overall race time to an accuracy of 1ms. This data will be displayed on seven-segment displays.

3.0 PROJECT MANAGEMENT

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This section will provide time tables for which the project will follow. These time tables include an overall snap shot of the scope of the project while going in depth for milestones, deliverables, and Gantt chart.

Table 8. Project Overview (1 of 2)

January Schedule			
Week of the 25 th	Milestone - Hardware	Milestone - Software	Deliverable
	Display Demo	Flow and Hierarchy Charts	Functional Block Diagrams
February Schedule			
Week of the 1 st	Milestone - Hardware	Milestone - Software	Deliverable
	Signal Processing Demo	Timing Demo	
8 th			GUI Mockup
15 th	Tagging Demo		Peripheral Initial Schematics
22 nd		Web Browser Demo	Peripheral Initial PCB

Table 9. Project Overview (2 of 2).

March Schedule			
Week of the	Milestone - Hardware	Milestone - Software	Deliverable
1 st	Peripheral PCB Demo		Test Plan
8 th		Communications Demo	Critical Design Review
15 th		Database Demo	Peripheral Final Schematic and Main Board Initial Schematic
22 nd		Race Algorithm Demo	Peripheral Final PCB and Main Board Initial PCB
29 th	Main Board PCB Demo	Wireless Registration Demo	Main Board Final Schematic
April Schedule			
Week of the	Milestone - Hardware	Milestone - Software	Deliverable
5 th		Reporting Demo	Main Board Final PCB
12 th	Enclosure Demo		Bill of Materials
19 th			Test Results
26 th			Final Demonstration with Working Prototype
May Schedule			
Week of the	Milestone - Hardware	Milestone - Software	Deliverable
3 rd			Final Documentation
10 th	--	--	--

3.1 Deliverables

These deliverables will be given to Paragon Innovations and are intended to provide the key information needed to understand the workings of the PWDMS.

Table 10. Deliverables.

Deliverable	Member Responsible	Delivered
Functional Block Diagrams	Kyle Mays	1/26/2010
System Hierarchy and Flow Charts	Uriel Maldonado	2/2/2010
GUI Mockup	Uriel Maldonado	2/9/2010
Peripheral Initial Schematics	Kyle Mays	2/16/2010
Peripheral Initial PCB	Kyle Mays	2/23/2010
Test Plan	Jason Belitz	3/2/2010
Critical Design Review	Jason Belitz	3/12/2010
Peripheral Final Schematic and Main Board Initial Schematic	Kyle Mays	3/16/2010
Peripheral Final PCB and Main Board Initial PCB	Kyle Mays	3/23/2010
Main Board Final Schematic	Kyle Mays	3/30/2010
Main Board Final PCB	Kyle Mays	4/6/2010
Bill of Materials	Josh Leatham	4/13/2010
Test Results	Jason Belitz	4/20/2010
Final Demonstration with Working Prototype	Josh Leatham	4/27/2010
Final Documentation	Josh Leatham	5/4/2010

Functional Block Diagram

Functional Block Diagrams will be created on two different levels. One diagram will outline the entire Pinewood Derby Management System as a whole. More in depth diagrams will also be created for the timing system start gate and finish line. Color will be used in the graphics to distinguish different components and purposes. The functional diagram outlining the entire PWDMS, will detail everything from the timing sensors and signal conditioning to the server and database communication with the PIC32 Microcontroller. The start gate and finish line diagrams will show in greater detail the

timing system and communication to the PIC32 Microcontroller. Created in Microsoft PowerPoint, these diagrams will be submitted to Paragon Innovations in both hard and soft copy.

System Hierarchy & Flow Charts

Hierarchy and Flow Charts for the created PWDMS software will be presented. These charts will show a brief description of the flow of the software code. Created with Microsoft PowerPoint and Microsoft Visio, these charts will be color coded and designed following the logic of the software code and its functions. The flow charts and hierarchy charts will be submitted in soft copy as well as a sectionalized hard copy.

GUI¹ Mockup

There are several management systems for the pinewood derby. In order to ensure that the program has the right feel, a GUI testing page will be made. The GUI testing page will be used in order to get feedback from the client. The testing page will be made using standard HTML tools and will be shown through a web browser such as Internet Explorer. Different methods will be used in order to create the interface. Tabbing, floating windows, and hyperlinks are just a few of the methods that will be employed. Graphics used will be a mixture of original and provided material.

The page will be posted on the team website and will be accessible to Paragon Innovations via password. A softcopy of all the files will also be emailed to the client in compressed form. The files will be organized so that when uncompressed, the client can use the files with little modifications to start using them. Any modifications to the source code will be noted by changing the text color to red and by making comments. A hard copy will be delivered as screen shots of the Mockup in PDF form.

Peripheral Initial Circuit Schematics

Circuit schematics will be designed and created for the timing sensors, signal conditioning hardware, tagging system, and display. The schematics will include all the

¹ Graphical User Interface

separate boards in the design namely: the finish line peripherals and the start gate peripherals. The overall schematic design and sub-circuits will be properly labeled and arranged in a logical design to allow for ease of reading and circuit comprehension. Using the National Instruments Multisim software, these schematics will be designed and delivered as separate entities as well as a complete schematic in both hard and soft copy in .pdf and original format.

Peripheral Initial PCB² Layouts

A Printed Circuit Board Layout for the start gate and finish gate will be created. The starting gate peripheral PCB will contain the start timing sensors as well as tagging peripherals and power management. The finish line will contain the finish gate timing sensors as well as the heart of the PWDMS. The PIC32 microcontroller, signal conditioning hardware, communication peripherals, and power management may, or may not, be included on the finish line PCB depending on the enclosure. If all devices do not fit neatly inside the custom enclosure, a main board will also be created and delivered. These designs will be created based upon the previously delivered schematics. Using the National Instruments Ultiboard software, these PCBs will be delivered separately in both hard and soft copy as well as gerber (.gbr) files of each of the board's layers.

Test Plan

The Test Plan for the PWDMS will encompass all aspects of the system which require testing. The test plan will be divided into four main divisions of testing: hardware, software, communications, and systems testing. Each of these sections will follow similar steps and documentation format, but the tests will be vastly different. Under the hardware section of testing, devices and components will be tested for connectivity and functionality. The software and communications sections will test the functionality of certain components and the system's ability to communicate with peripherals as well as outside computers. The overall systems testing will test the functionality of the complete

² Printed Circuit Board

system and will not take place until the previous sections of testing have been completed. A test matrix will also be created to ensure the completion of all functional requirements. This test plan will be created in the logical order of testing the boards and system as a whole. Documented with Microsoft Word, each test will be contained to a single page with the following information: test name, description of test, location of device, test parameters, and any other necessary information needed, such as limits. The document will be submitted in both hard and soft copy.

Critical Design Review

The Critical Design Review will be a 40-minute slideshow presentation detailing the progress of the PWDMS project. Given at a to-be-determined location and time, this presentation will be made to the sponsor, Paragon Innovations, as well as advisors Dr. Fink and Dr. Hasan. The presentation will state the time and budget status using scheduled performance and cost performance indices. Remaining work and technical challenges will also be listed and described. In addition to a presentation, progress will be demonstrated such as any functioning hardware created by that point, flow charts, and schematics, et cetera. The Critical Design Review will be taped and recorded for future viewing and reference.

Peripheral Board Final Schematic and Main Board Initial Schematic

The peripheral board final schematic will retain the same requirements and abilities as the originally submitted schematics. These final schematics will also contain the many revisions necessary for all requirements of the PWDMS to be met as well as simple aesthetic revisions. The peripheral board final circuit schematics will be submitted as the originals in both hard and soft copy.

In addition, if not incorporated into the finish gate, the main board initial schematic will be created using the same guidelines as the peripheral schematics. It will incorporate the PIC microcontroller as well as the communication system and any other necessary hardware. The overall schematic design will be properly labeled and arranged in a logical design to allow for ease of reading and circuit comprehension. Using the National

Instruments Multisim software, these schematics will be designed and delivered as separate entities as well as a complete schematic in both hard and soft copy in .pdf and original format.

Peripheral Board Final PCB and Main Board Initial PCB

The peripheral board final PCB Layout will retain all of the same previously stated requirements of the peripheral circuits. These layouts will contain all peripheral circuit board designs not located on the main PCB. The revised/final layouts will contain the revisions, both functional and aesthetic, from the original designs. The peripheral board final PCB Layout will be submitted in both hard and soft copy complete with gerber (.gbr) files of each layer.

The main board initial PCB, if not incorporated into the finish gate layout, will retain the same requirements and abilities as the originally submitted layouts. The layout will be submitted as the originals in both hard and soft copy complete with gerber (.gbr) files of each layer.

Main Board Final Schematic

The main board final schematics will retain all of the same previously stated requirements of the main circuit. These schematics will contain all main circuit designs not located on the peripheral PCB. The revised/final schematics will contain the revisions, both functional and aesthetic, from the original designs. The peripheral board final schematics will be submitted in both hard and soft copy.

Main Board Final PCB

The main board final PCB layout will retain all of the same previously stated requirements of the main board circuits. These layouts will contain all main circuit board designs not located on the peripheral PCB. The revised/final layouts will contain the revisions, both functional and aesthetic, from the original designs. The main board final PCB layout will be submitted in both hard and soft copy complete with gerber (.gbr) files of each layer.

Bill of Materials

A Bill of Materials will be created for each of the components of the PWDMS. The Bill of Materials will contain a detailed list of every component found on the boards, their individual costs, item descriptions, and the cost of creating the board itself. The Bill of Materials will also include the pricing for 100 units with cost of population of PCBs. Created in a spreadsheet from Microsoft Excel, the Bill of Materials will be organized in a logical breakdown separated by component type, value, and price. The Bill of Materials for each component of the PWDMS will be submitted in both hard and soft copy.

Test Results

After prototype and systems testing, the results will be verified and documented for verification that all requirements of the PWDMS have been met. The documentation will follow the same progression as the original test plan. Each test performed will have its own page with a description of the test, how it was performed, the tested parameters, and the results of the test. These tests will consist of hardware, software, and systems testing. The documentation will be submitted in both a hard and soft copy.

Final Demonstration with Working Prototype

At the end of development of the PWDMS, Valance Solutions will have a fully-functioning prototype to demonstrate. This demonstration will be conducted in the presence of the full Valance Solutions team as well as the sponsor, Paragon Innovations, and advisors Dr. Fink and Dr. Hasan. The demonstration will consist of mimicking a Pinewood Derby's registration and race management capabilities to their full extent. The demonstration will focus on accurately achieving each of the requirements set for the PWDMS and demonstrating them in working condition. A presentation will also be given explaining the completion of the project, the budget, the timeline, and the developed prototype itself. While the demonstrations and presentation will be recorded, the physical slideshow, created in Microsoft PowerPoint, will be submitted in both hard and soft copy.

Final Documentation

The final documentation for the PWDMS Project will contain a complete overview of the entire project from development and design to the completed prototype. The project summary, complete descriptions of each of the units, test plan and results, all deliverables submitted, project timelines, user manual, source code, user guide for GUI, bill of materials, relevant sections of component datasheets, unit schematics and unit PCB layouts will all be included in this documentation. The purpose of this final documentation is to give the reader the overall scope of the project in its entirety. Every aspect of the project will be covered within this final document. The document will be professionally bound and submitted in both a hard and soft copy.

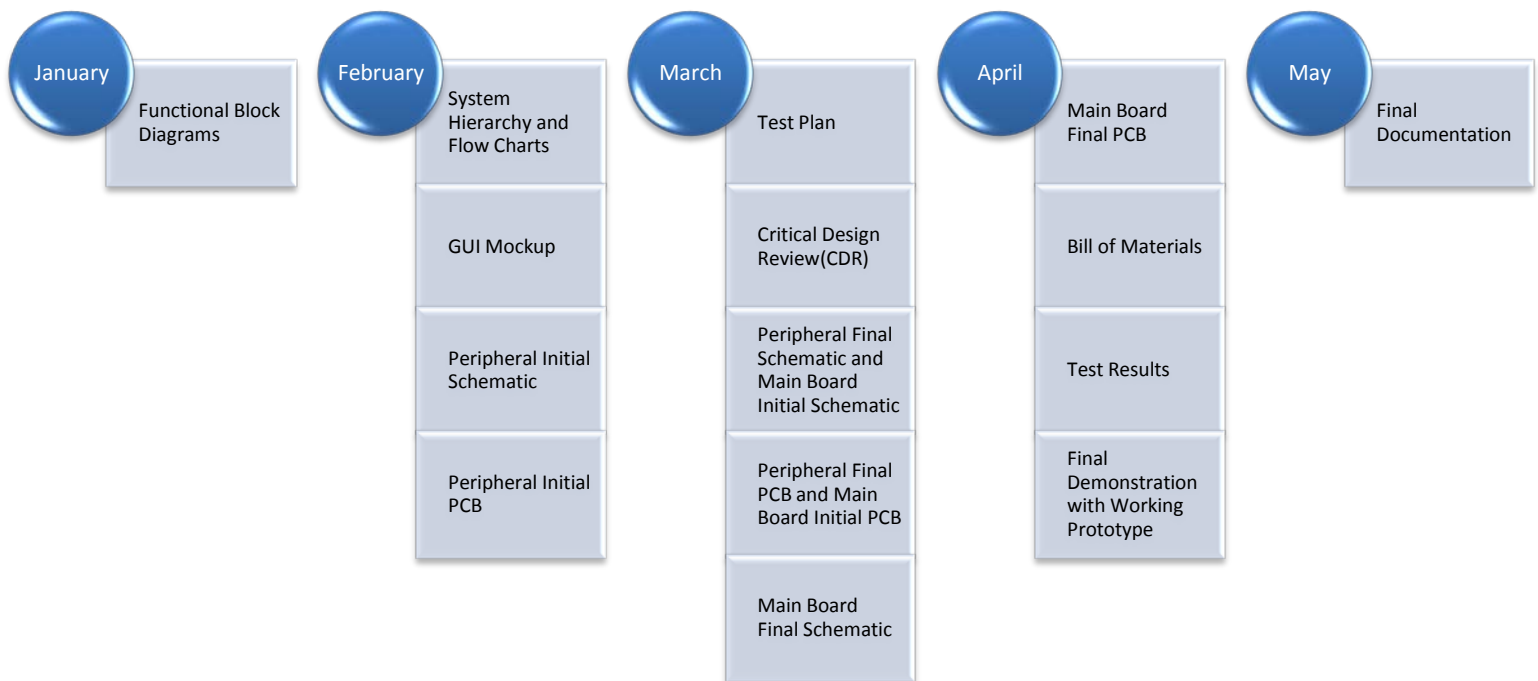


Figure 4. Deliverables -- Graphical Timeline.

3.2 Milestones

Milestones are demonstrations that will be presented to either the advisors or sponsor that will verify prototype progress. Although valuable in displaying progress, these milestones are differentiated from deliverables because they do not add actual value to the sponsor. The following two tables list the different hardware and software milestones that will take place over the course of the project.

Table 11. Milestones -- Hardware.

Hardware Milestones	Member Responsible	Demonstrated
Display Devices Demo	Josh Leatham	1/26/2010
Signal Processing Demo	Kyle Mays	2/5/2010
Tagging System Demo	Jason Belitz	2/16/2010
Peripheral PCB Demo	Kyle Mays	3/3/2010
Main Board PCB Demo	Kyle Mays	3/26/2010
Enclosure Demo	Jason Belitz	4/13/2010

Table 12. Milestones -- Software.

Software Milestones	Member Responsible	Demonstrated
Flow and Hierarchy Charts	Uriel Maldonado	1/22/2010
Timing Demo	Josh Leatham	1/24/2010
Web Browser Demo	Uriel Maldonado	2/26/2010
Communications Demo	Jason Belitz	3/9/2010
Database Demo	Uriel Maldonado	3/18/2010
Race Algorithm Demo	Jason Belitz	3/21/2010
Wireless Registration Demo	Jason Belitz	4/1/2010
Reporting Demo	Uriel Maldonado	4/9/2010

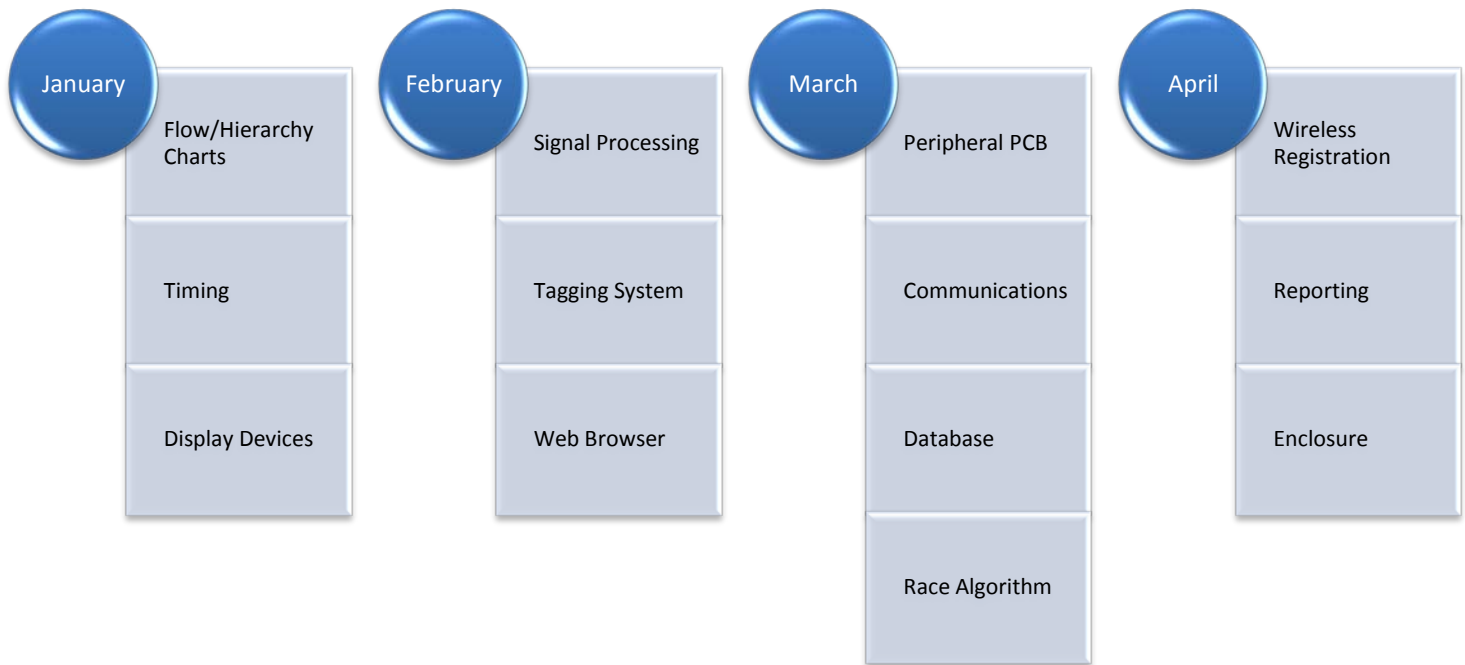


Figure 5. Milestones – Graphical Timeline.

3.3 Gantt Chart

The Gantt chart provides a time frame for the different stages of the project.

ID	Task Name	Start	Finish	Duration	Jan.	Feb.	March	April
1	Research	01/11/10	01/17/10	7d				
2	Hardware	01/18/10	03/28/10	70d				
3	Management System	01/18/10	03/19/10	61d				
4	Communication	02/08/10	03/19/10	40d				
5	Testing	01/27/10	04/9/10	73d				
6	Wrap-Up	03/29/10	04/30/10	32d				

Figure 6. Gantt Chart.

Following the guidelines in this document, Valance Solutions will provide a fully working prototype of the PWDMS product on April 27th, 2010 with the final documentation provided on May 4th. The prototype is currently scheduled to be completed on time, and under budget.

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